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Space Administration

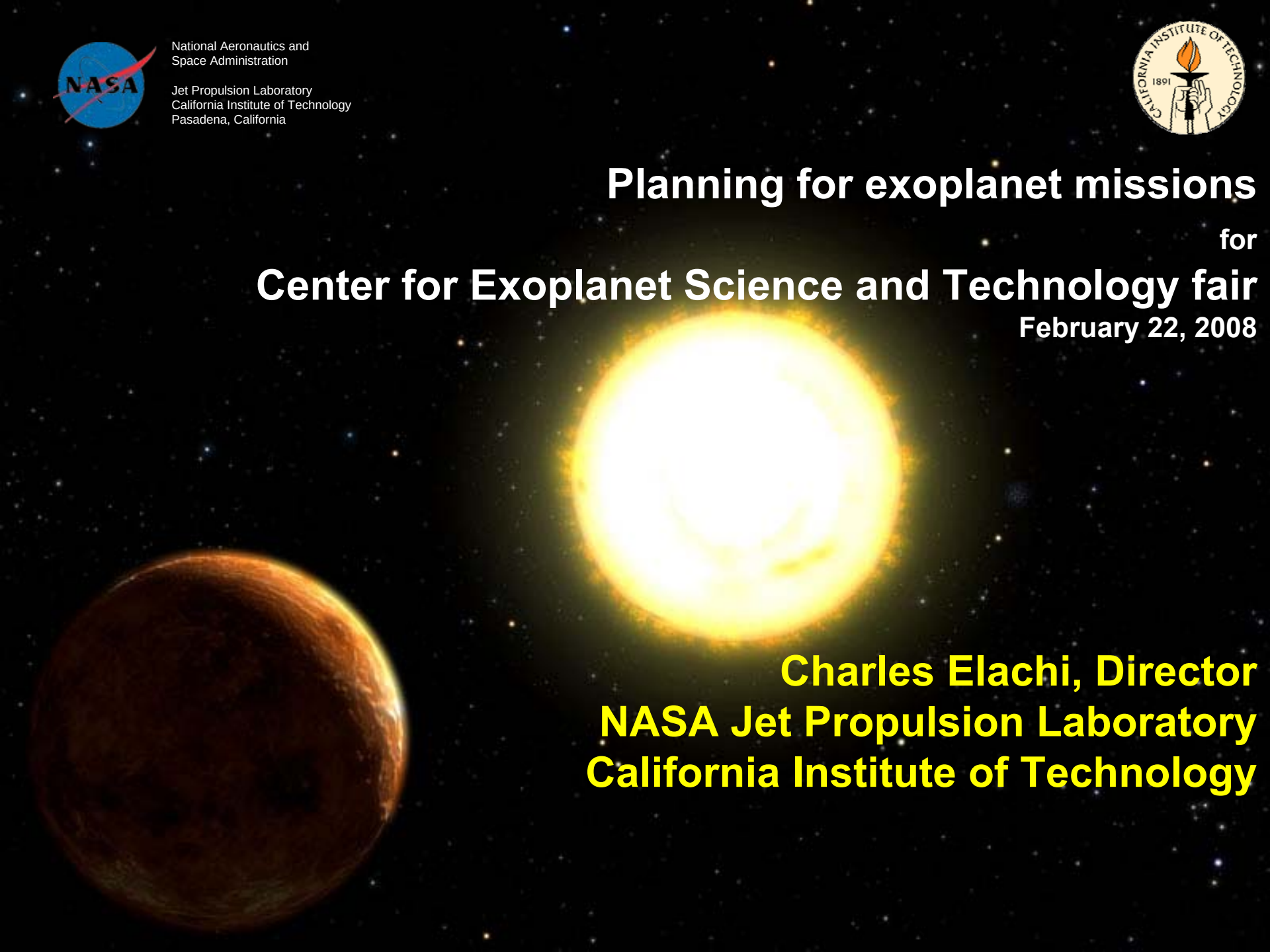
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Planning for exoplanet missions

for

Center for Exoplanet Science and Technology fair

February 22, 2008



Charles Elachi, Director
NASA Jet Propulsion Laboratory
California Institute of Technology

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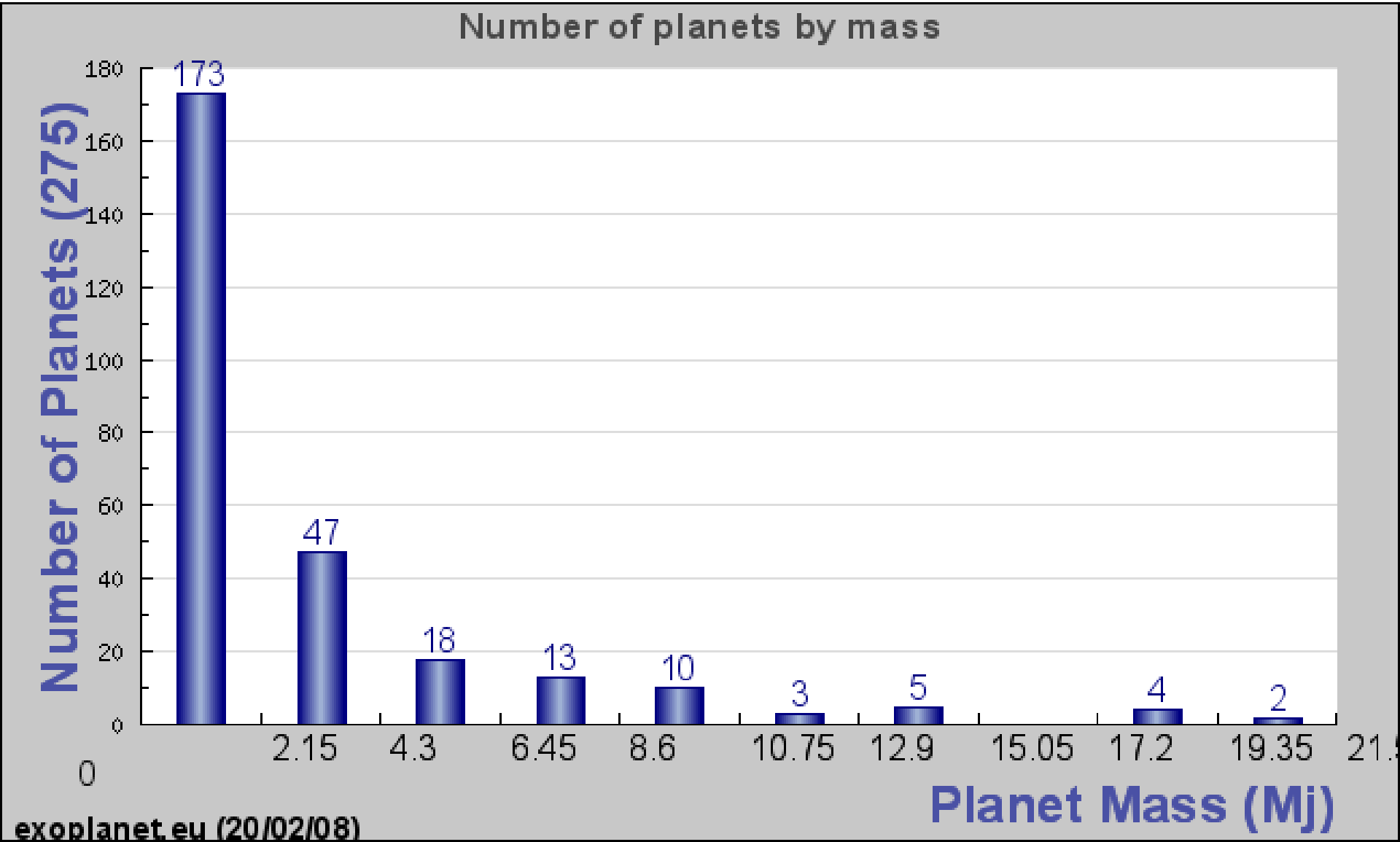
275 exosolar planets detected by February 2008



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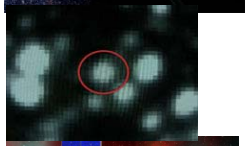
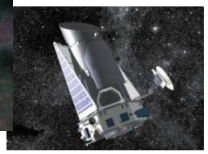
Exoplanet exploration techniques

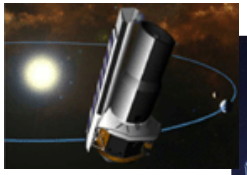
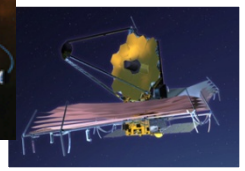
- **Stellar reflex motion**
  - **Radial Velocity**
  - **Astrometry**
- **Photometry**
  - **Microlensing**
  - **Transits**
- **Spectral characterization and imaging**
  - **Transits**
  - **Visible nulling**
  - **Infrared nulling**


Keck and other observatories

Space interferometry

CoRoT and Kepler

Spitzer, Hubble, and Webb Space Telescopes


Visible coronagraphs and occulters; and infrared nulling interferometers

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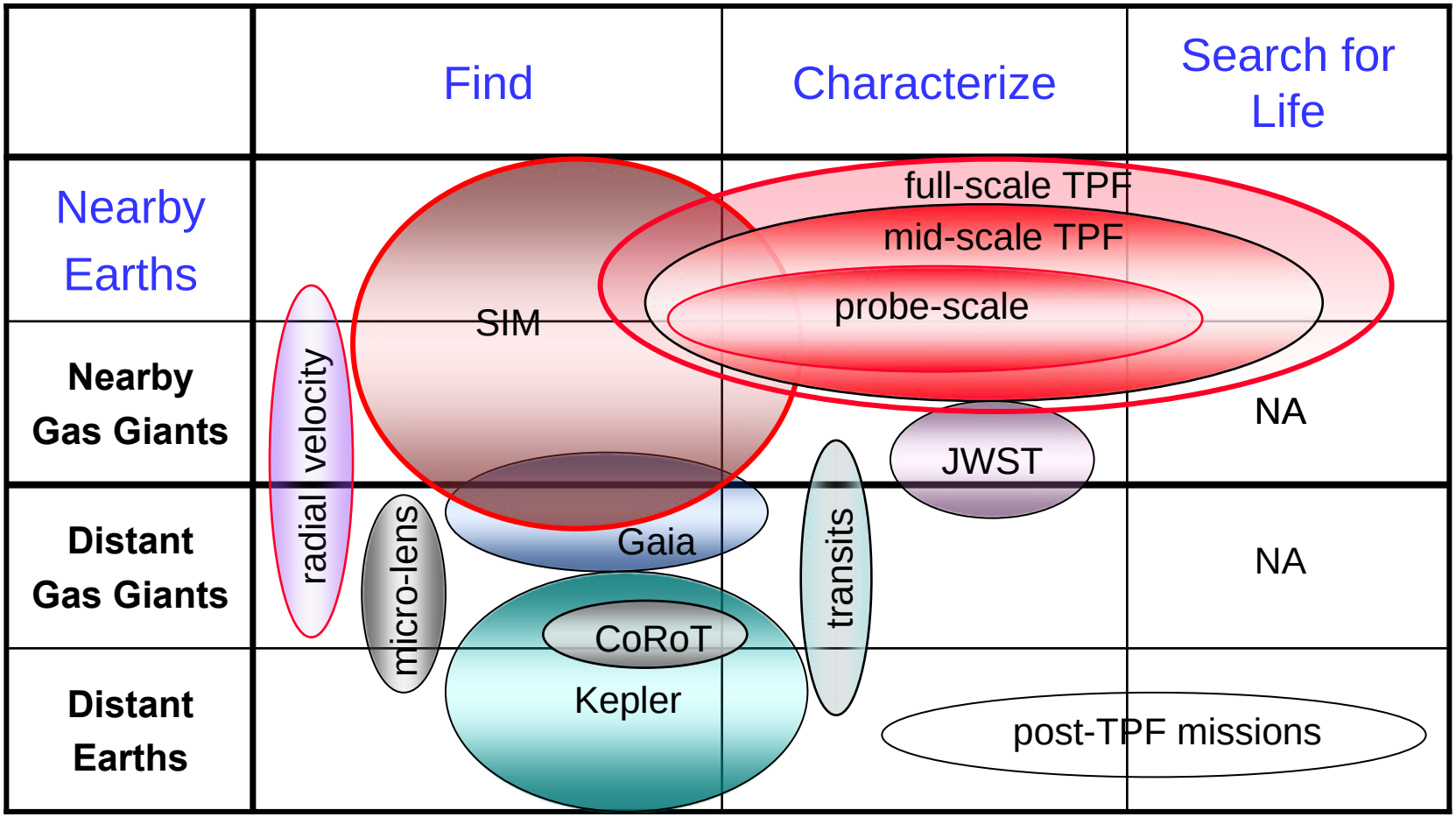
Exoplanet-mission phase space



We will have a family portrait of the neighboring few thousand planetary systems

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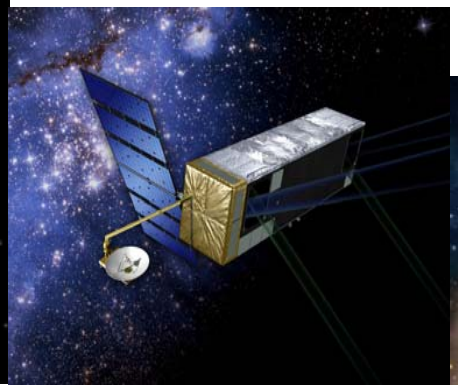
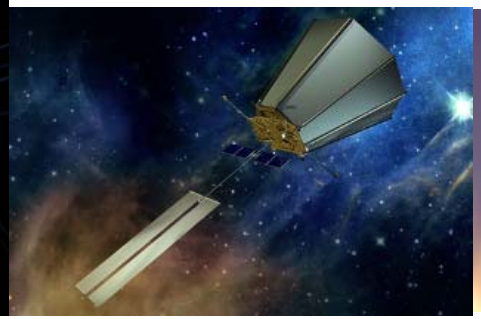
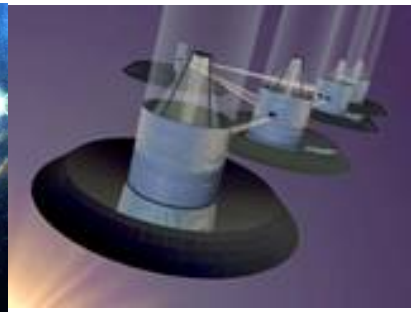
Future exoplanet missions

Kepler:
- Identify Earth-sized planets transiting across 100,000 stars
- Launch early 2009

Space Interferometry Mission (SIM):
- Search 65 nearby stars for Earths (<30 l.yr.)
- 1000 stars for planet formation vs. spectral type.
- Architecture of planetary systems.
- Young star planet formation and migration processes.
- Provide masses and orbits.

Terrestrial Planet Finder (TPF):
- Characterize temperature, size, and composition of other Earth-like planets
- Look for signatures of life
- ***Coronagraph:*** Visible light high contrast imaging to block starlight
- ***Interferometer:*** Mid-IR interferometer with 4-beam nulling to block starlight

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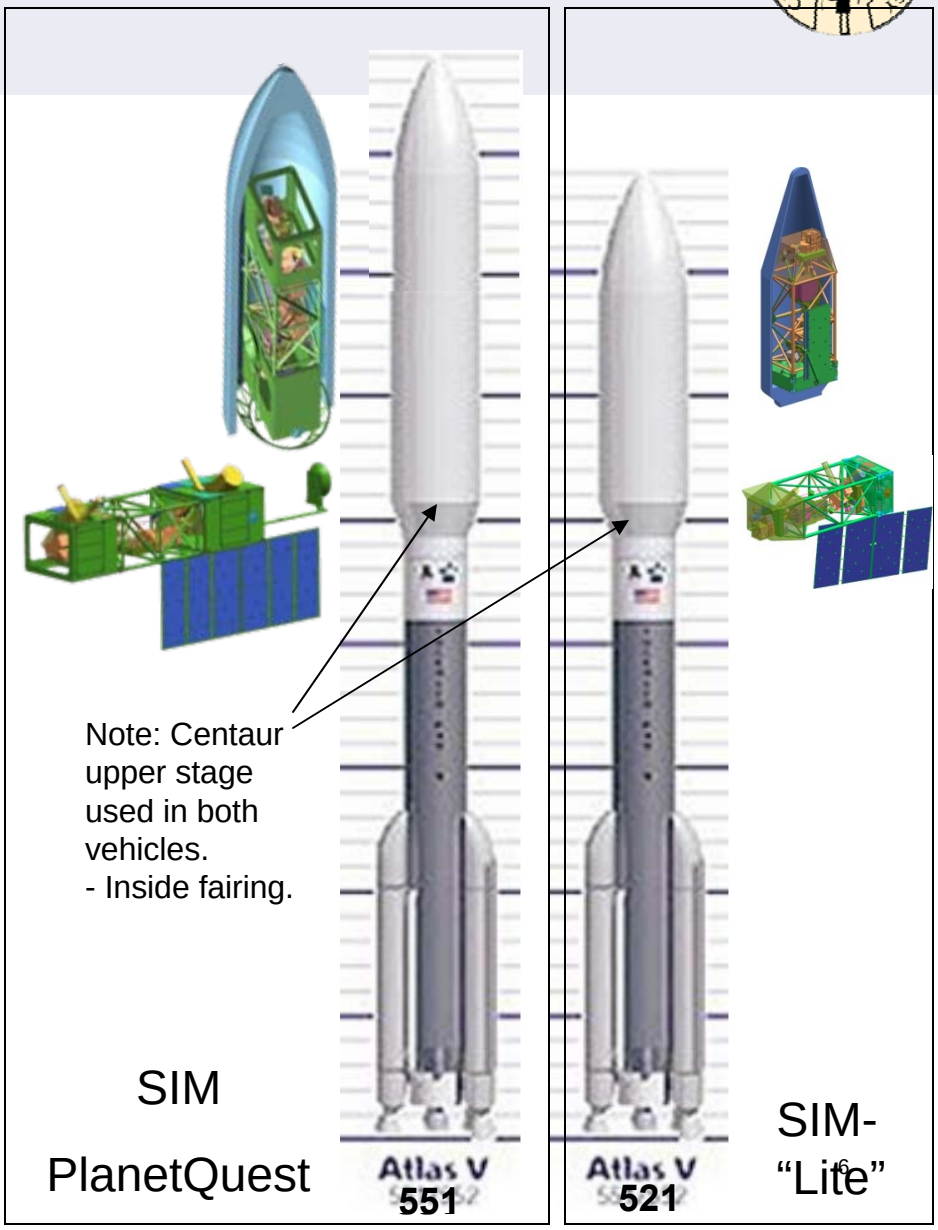
SIM-PlanetQuest vs. SIM-"Lite"

Parameter	SIM PlanetQuest	SIM- "Lite"
Wide Angle Astrometric Accuracy	2.4 μas	4.0 μas
# targets relative to SIM PQ	-	~50%
Narrow Angle Astrometric Accuracy	0.7 μas	1.00 μas
Star Visual Magnitude	<20+	<20
#Stars Surveyed for 1Mearth/HZ	130	65
Mass (including contingency)	6800kg	4300kg
Number of Interferometers	3	2
Science Baseline	9m MSI*	6m MSI*
Guide-1 Baseline	7.2m MSI*	4.2m MSI*
Guide 2	7.2m MSI*	30cm T-scope
Power (including contingency)	6kw	6kw
Intermediate Class Launch Vehicle	Largest	Medium
LV Fairing size	5mx19m	5mx11m
Orbit:	ETSO**	ETSO**
Planned operations	5 yrs	5 yrs
Life limiting Consumables	Propellant	Propellant
NPR8705.4 Payload Risk Class	A	B
Schedule (BCD, to-go)	77mo	58mo
BCD Cost-to-Go, w/LV [FY08$]	$1470M	$940M†
Mission Operations [FY08$]	$400M	$170M†

* MSI = Michelson Stellar Interferometer

•• ETSO = Earth Trailing Solar Orbit (ala SPITZER).

† Current best estimate.



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Exoplanet mission planning status

- Exoplanet Task Force draft report issued February 11.
  - Astrometric mission likely to be recommended.
  - Future missions also seen as desirable:
    - Terrestrial Planet Finder
    - Smaller exoplanet missions like those discussed at 2007 Exoplanet Forum (~$700M-class missions):
      - Coronagraphs
      - Astrometric
      - Transit telescopes
      - Interferometric
    - 2007 NASA call for Astrophysics Strategic Mission Concept Studies proposals (like those above)
      - Selection of 19 for study announced 2/15/08.

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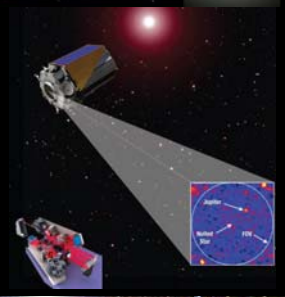
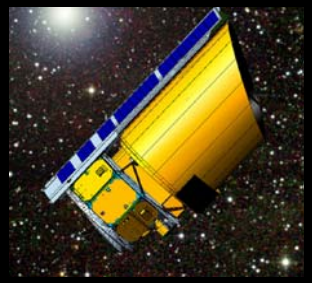
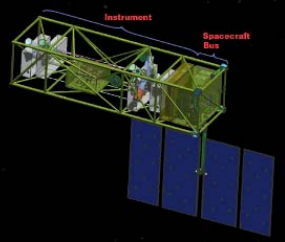
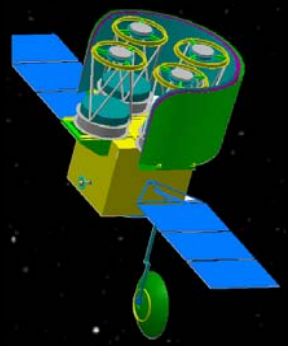
Selected future missions

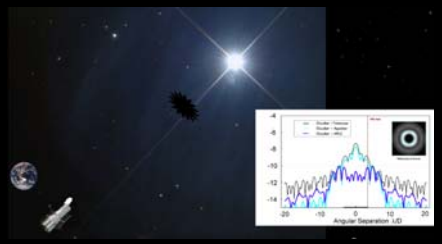
- New Worlds Observer; PI: Webster Cash (U of Colorado)
- Extrasolar Planetary Imaging Coronagraph; PI: Mark Clampin (NASA GSFC)
- Pupil-Mapping Exoplanet Coronagraphic Observer PI: Olivier Guyon (U of Arizona)
- Planet Hunter; PI: Geoff Marcy (UC Berkeley)

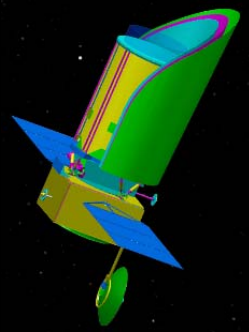












- Dilute Aperture Visible Nulling Coronagraph Imager PI: Michael Shao (JPL)
- XPC; PI: David Spergel (Princeton)
- Actively-Corrected Coronagraph for Exoplanet System Studies; PI: John Trauger (JPL)

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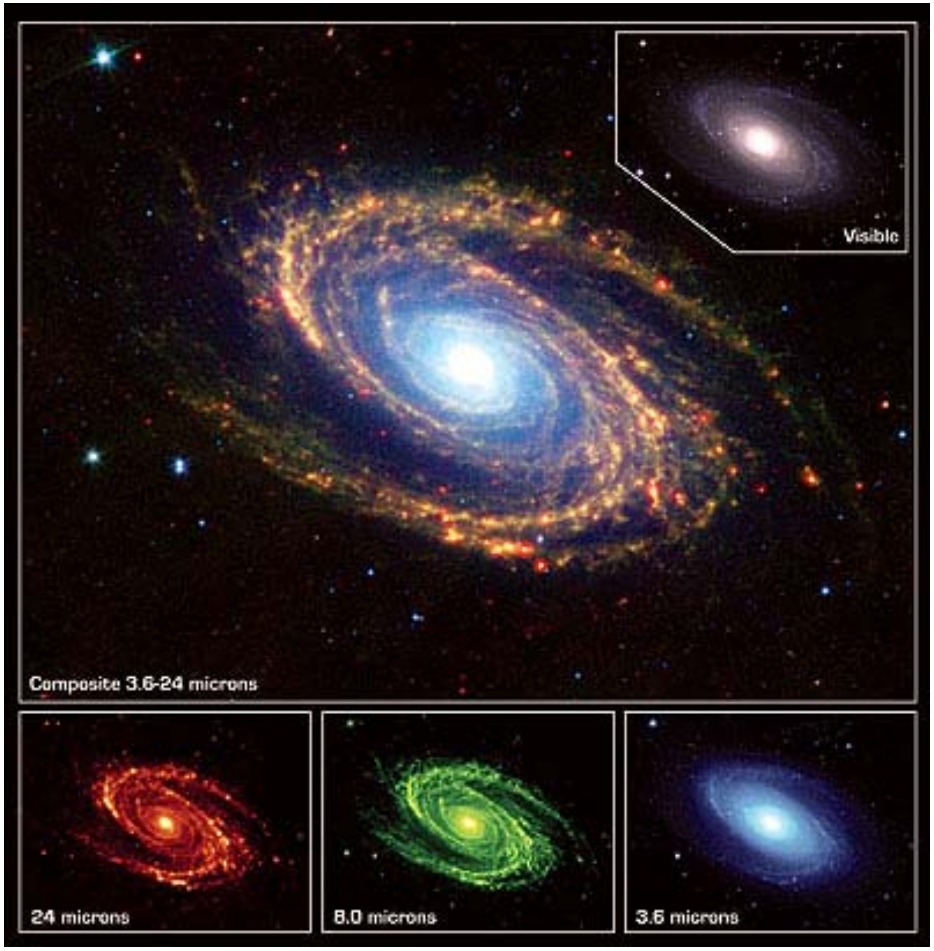
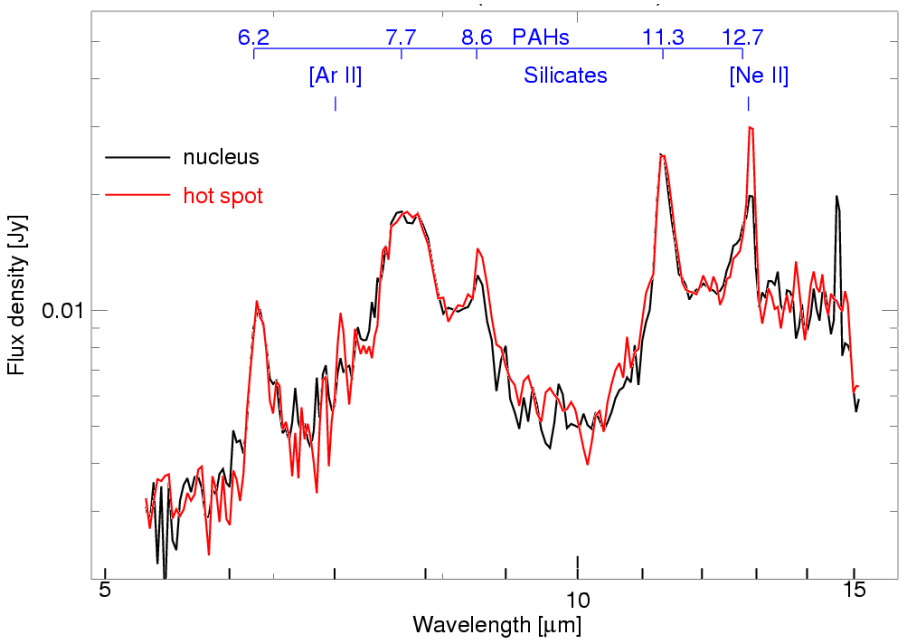
Spiral galaxy M81, 12 million light years away, in Ursa Major, as seen by Spitzer





M81 has a spectrum with an 8μm bump indicating polycyclic aromatic hydrocarbons (e.g., diesel exhaust or barbecue grill gunk).